NAVAL POSTGRADUATE SCHOOL
Monterey, California

EC 3550 FINAL EXAM 12/99 Prof. Powers

- This exam is open book and notes.
- There are four problems; each is equally weighted.
- Partial credit will be given; be sure to do some work on each problem.
- Be sure to include units in your answers.
- Please circle or underline your answers.
- Show *ALL* work.
- Write only your name on this sheet.
- Exams and course grades *should* be available outside the Optical Electronics Laboratory (Bu 224) on **Friday afternoon, 17 December**.
- Enjoy your break!

Course grade: ______________

1		3	
2		4	
TOTAL			

Name: ____

1. Please provide brief, concise answers to the following questions. (Long, verbose answers are *not* required.)

   - List three advantages that a laser diode has over a LED source in a fiber link.
   - List two disadvantages that a laser diode has compared to a LED source in a fiber link.
   - List one advantage that a graded-index multimode fiber has when compared to a step-index multimode fiber.
   - List one advantage that a step-index multimode fiber has when compared to a graded-index multimode fiber.
   - List one advantage that an APD detector has when compared with a pin-diode detector.
   - List four disadvantages that an APD detector has when compared with a pin-diode detector.

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2. Consider the fiber link shown in Fig. 1 operating at 1550 nm. Each splice has a loss of 0.5 dB. Each segment (loop) of fiber is 22 km long and the fiber loss is 0.25 dB/km at the operating wavelength. The power in the fiber at the transmitter is 15 μW. The amplifier parameters are given below. All pigtail fiber losses are ngligible

   Find the (minimum) BER of this link. (You may assume that the dominant sources of noise are the beat noises between the ASE and the signal and the beat noise between the ASE with itself.)

Parameter	Value
G	30 dB (for all values of P_{in}
n_{sp}	2
$\Delta\nu$	3.74 THz (3,740 GHz)
B_o	100 GHz

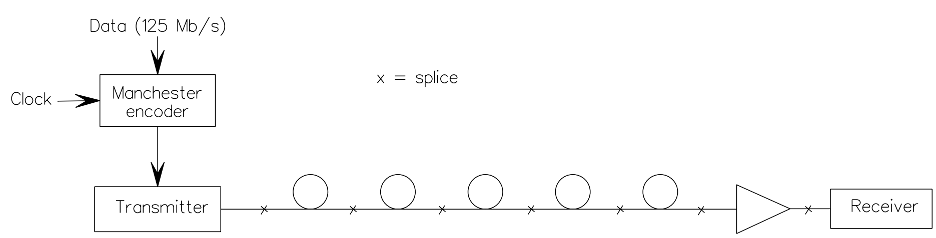

Figure 1: Fiber link for Problem 2.

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3. Consider the fiber link shown in Fig. 2 operating at 1300 nm. The input power in the fiber at point "A" is +3.7 dBm. The splice losses are each 0.7 dB. The gain of the amplifier vs. the normalized input power is shown in Fig. 3a. The saturation power of the amplifier is -10 dBm.

The excess loss of the splitter from any input to any output is 1 dB. The loss matrix for the circulator is given in Table 1. The reflectivity of the Bragg grating device is shown in Fig. 3b. All fiber pigtail losses are negligible. The power required at a receiver to achieve the desired BER is

$$P_R[\mathrm{dBm}] = -55.0 + 10\log\left(B'_R[\mathrm{Mb/s}]\right)$$

If a receiver is placed at point "C", calculate the maximum bit rate that can be supported by this system.

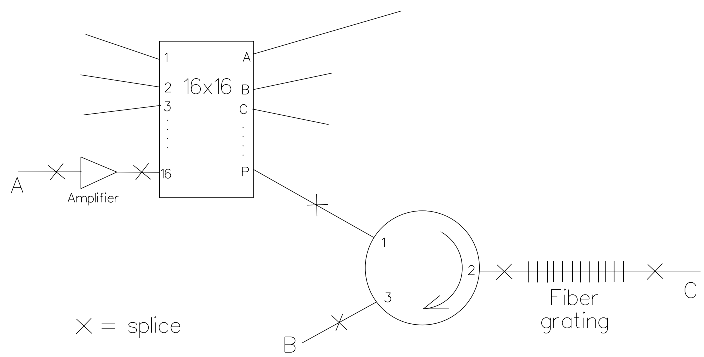

Figure 2: Component connection for Problem 3.

	Output 1	2	3
1	—	0.7	90
2	90	—	0.6
3	0.8	90	—

Table 1: Measured loss matrix (in dB) for optical circulator of Problem 3. The inputs are on the left; the outputs are across the top.

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4. A 7/125 singlemode-fiber link operates at 1500 nm with a fiber loss of 0.8 dB/km. The fiber has a core index of 1.460 and a fractional difference in the index of refraction of 0.55%. The source is a laser with a linewidth of 0.8 nm and provides −3 dBm of power in the fiber. The data coding in NRZ. The power required by the receiver to achieve the desired BER is given by

$$P_R[\mathrm{dBm}] = -59.0 + 9\log\left(B'_R[\mathrm{Mb/s}]\right)\ .$$

Set up an equation that will allow you to find the bit rate at which the fiber will change from being attenuation-limited to dispersion-limited. You do *not* need to solve your equation.

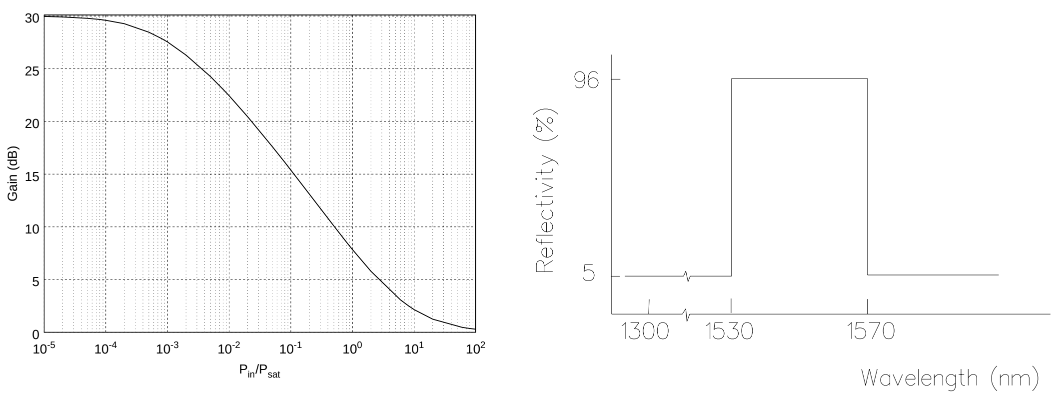

Figure 3: Problem 3: (a) Gain vs. normalized input power of fiber amplifier and (b) Reflectivity vs. wavelength for fiber grating (idealized).

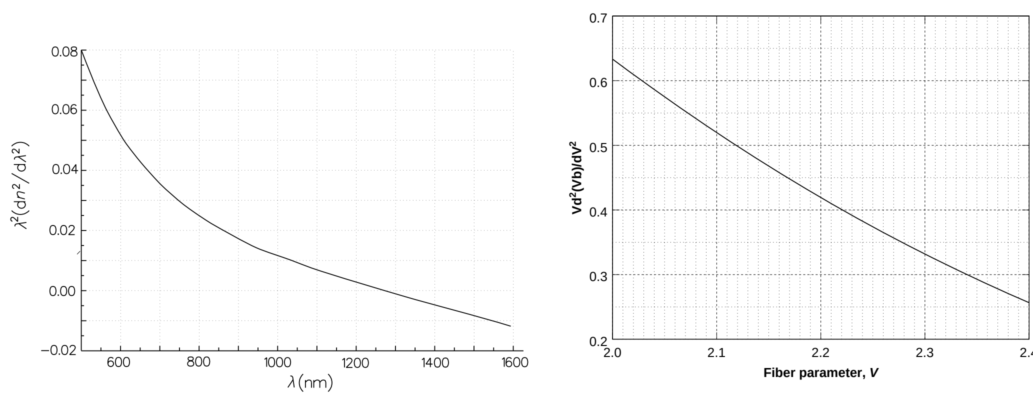

Figure 4: (a) Fig. 3.8 of text and (b) Fig. 3.10 of text.